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American Meteorological Journal.

A Monthly Review of Meteorology, Medical Climatology and Geography.

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THE AMERICAN
METEOROLOGICAL JOURNAL.

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CURRENT NOTES.

THE readers of the JOURNAL will please note that all mail should be sent, either to Prof. M. W. Harrington, Ann Arbor, Mich., or to the Meteorological Journal Co., Ann Arbor, Mich. Mail which has been sent to the old address in care of the W. H. Burr Publishing Co., Detroit, has been detained there from one to three months.

CABOT STRAITS, NEWFOUNDLAND.—The strait that separates Cape Breton Island from Newfoundland, has gone without a a name until a year or two ago, when the name of Cabot Straits was given to it on the English Admiralty Charts. This is in honor of the discoverers.

THE MONTHLY WEATHER REVIEW of the Signal Service has been much improved latterly and now presents a handsome appearance. The large folded chart of paths of areas of low pressure, tracing them across the Atlantic, is a great improvement on the earlier ones. The issue of this Review is now to be limited so far as practicable; as its distribution is gratuitous it will hereafter be sent only to those who are entitled to it and also prize it.

TORNADOES.—Lieutenant Finley has lately published a book for popular reading on this subject. The book is issued

by the *Insurance Monitor*, of New York, and, although small, it is condensed and contains the results of many years' labor, and the examination of more than five thousand storms. The book is a most excellent one and, though it lends itself easily to quotation, it is so accessible to all our readers that we refrain. We commend it to our readers and anticipate for it a very large sale.

SUBMARINE FRESHWATER SPRINGS are known in many places. A curious way of getting water from them is related by the Bishop of Wellington, as it is practiced on some of the coral islands of the south seas, as Naugone, when no water can be got on the surface. He says two men go out together to sea, and dive down at some spot where they know there is a fresh-water spring, and they alternately stand on one another's back to keep down the one that is drinking at the bottom before the pure water mixes with the surrounding salt-water.—*Journal Ethn. Soc., London, N. S. I, 371.*

THE 26-DAY PERIOD OF TERRESTRIAL MAGNETISM.—That the elements of terrestrial magnetism had a period of 26 days has been long known. To Dr. Liznar belongs the credit of showing that this period is much more sharply marked in higher latitudes,—that it becomes more and more clear, in fact, as we approach the magnetic pole. Dr. Liznar investigated the period for Fort Rae (Lat. 62° 39′ N.) and Jan Magen (Lat. 70° 59′ N.) and found it, in the mean, 25.85 days. This period corresponds closely with that of the rotation of the sun, and Dr. Liznar thinks that a sufficiently long series of observations would show a variation of its amplitude in periods of eleven years, or the period of maximum sun-spots.

RARE ELECTRICAL PHENOMENON AT SEA.—Capt. C. D. Swart, of the Dutch bark, "J. P. A.," makes the following report of a remarkable phenomenon observed by him at 5 P. M., March 19, 1887, in N. 37° 39′, W. 57° 00′:

"During a severe storm saw a meteor in the shape of two balls,

one of them very black and the other illuminated. The illuminated ball was oblong, and appeared as if ready to drop on deck amidships. In a moment it became as dark as night above, but below, on board and surrounding the vessel, everything appeared like a sea of fire. The ball fell into the water very close alongside the vessel with a roar, and caused the sea to make tremendous breakers which swept over the vessel. A suffocating atmosphere prevailed and perspiration ran down every person's face on board and caused every one to gasp for fresh air. Immediately after this solid lumps of ice fell on deck, and everything on deck and in the rigging became iced, notwithstanding that the thermometer registered 19° Centigrade. The barometer during this time oscillated so as to make it impossible to obtain a correct reading. Upon an examination of the vessel and rigging no damage was noticed, but on that side of the vessel where the meteor fell into the water the ship's side appeared black and the copper plating was found to be blistered. After this phenomenon the wind increased to hurricane force."—*Monthly Weather Review.*

THE BELLE PLAINE ARTESIAN WELL.—In the spring of 1886 it was found that good wells could be obtained in the drift about Belle Plaine and six were put down to the depth of 200 or 300 feet, the most of which were flowing wells. In August a seventh well was sunk at a level of 15 to 30 feet below the flowing wells already down. At a depth of 193 feet a large body of water was struck and this burst out with destructive violence. The height reached by the column was only three or four feet, but the quantity of water was great, being perhaps 5,000,000 gallons per day. The other wells declined steadily and soon ceased to flow. It was evident that there was a large body of water in the lower strata of the drift and that the new well was drawing it off.

From this time on the chief interest in the well lay in the unsuccessful attempts to control it. Pipes sank out of sight as did the thousands of loads of sand and stone which were emptied into it. Meantime the flow declined somewhat, but still continued large. But it was only in May last, nine months after

the outburst, that the well was finally controlled. The water now flows through a five inch pipe and can be turned off at will.

A peculiar fact regarding this well is said to be its seeming breathing, which is as regular as a clock, and at a rate of forty to fifty pulsations per minute. This has been noticeable ever since the first break, and is more so now since the water comes direct through the casing.

ROYAL METEOROLOGICAL SOCIETY.—The usual monthly meeting of this Society was held on Wednesday, the 18th of May, at the Institution of Civil Engineers, 25 Great George street, Mr. W. Ellis, F. R. A. S., President, in the chair.

Mr. A. S. Morriatt and Capt. Paul Mordovin were balloted for and duly elected Fellows of the Society.

The following papers were read:

(1) "Brocken Spectres and the Bows that often accompany them," by Mr. H. Sharpe. The author has collected all the original descriptions of the Brocken Spectre, which is really the shadow of the observer cast by the sun upon clouds. In some cases the shadow is surrounded by a bow, which the author shows is like the rainbow in color and in the order of colors. The head of a shadow is sometimes surrounded by another sort of phenomenon touching the head, and which the author names the "glory."

(2) "Results of Thermometrical Observations made at 4 feet, 170 feet, and 260 feet, above the ground at Boston, Lincolnshire, 1882-'86," by Mr. W. Marriott, F. R. Met. Society. These observations were made on Boston Church Tower which rises quite free from any obstructions, in a very flat country, to the height of 273 feet. A Stevenson screen with a full set of thermometers was placed 4 feet above the ground in the churchyard, a similar screen and thermometers was fixed above the belfry at 170 feet above the ground, while a Siemens electrical thermometer was placed near the top of the tower, the cable being brought down inside and attached to a galvanometer on the floor of the church where the indications were read off. The results showed that the mean maximum temperature at 4 feet

exceeds that at 170 feet in every month of the year, the difference in the summer months amounting to 3°; while the mean minimum temperature at 4 feet differs but little from that at 170 feet, the tendency, however, being for the former to be slightly higher in the winter and lower in the summer than the latter. As the electrical thermometer was read usually in the day time, the results naturally showed that the temperature at 4 feet during the day hours was considerably warmer than at 260 feet. The author, however, detailed several sets of readings which had been made during the night as well as the day, the results from which were of a very interesting character.

(3) "Snow Storm of March 14th and 15th, 1887, at Shirenewton Hall, near Chepotow," by Mr. E. J. Lowe, F. R. S.

During the evening the President made a presentation to Dr. J. W. Tripe of a silver tea and coffee service, which had been subscribed for by the Fellows in acknowledgment of the many services which he had rendered to the Society during a period of over thirty years.

EARTHQUAKES AND VOLCANOES.—The scientific *feuilletoniste* of the *Journal des Debats* publishes a new law of relations between the moon and earthquakes. He finds, as a matter of statistics, that well-characterized earthquakes occur exactly at (1) *Equilune*, or when the moon is in the plane of the equator, or (2) *Lunistice*, when the moon is in its greatest declination from the equator, or (3) when the sun and moon have the same declination. There is never more of a variation than a day, or possibly two, from the dates of the above phenomena, though the author's investigations have extended back to 1752. Thus, the Andalusian earthquake of Dec. 25, 1884, corresponds to an equilune, that of Ischia, 28 July, 1883, to a northern lunistice, that of Krakatoa, August 26, 1883, to a southern lunistice. The Cachemire earthquake, June 24, 1885, which destroyed 70,000 houses, fell on a southern lunistice, when the moon was in perigee; that of Iquique, 13 August, 1808, was also on a lunistice, as also was that in San Francisco, on October 21, of the same year. The terrible Lisbon earthquake, November 1, 1755, oc-

curred exactly at the equilune, as also that at Nice, February 16, 1752. The author also finds that the recent earthquakes fall also on these critical periods. The Arizona earthquake of May 3rd, has occurred since the above views were published. Turning to the Nautical Almanac, it proves to have been on (within a few hours of) an equilune, immediately followed by a perigee. The chief features of interest concerning this earthquake are, (1) It occurred in a region where the topography showed that earthquakes must have been rare for many ages and was accordingly accompanied by enormous landslides and other changes of surface. (2) Following it came a new volcano in Sonora, immediately to the south of Arizona. This volcano is in the Sierra Madre Mountains (the main divide of the continent), near the hamlet of Bavispe. When visited the crater was pouring forth an immense volume of smoke, fire and lava, and boiling water was issuing from the side of the mountain, which had destroyed all vegetation in the valleys in the vicinity, and large boulders were hurled down from the crater. The noise was terrific, like a number of engines at work accompanied by sounds of thunder, and the air was dense with smoke and cinders. There are chasms in the earth, and all the roads and trails are wiped out. Not a bird or living thing could be seen within ten miles of the volcano. The town of Bavispe is a complete ruin. The people have all moved out on the high plains, and are living in tents in mortal fear. There has been a constant tremor and a continued series of shocks since the first earthquake. The center of the earthquake seems to have been in this vicinity, or about sixty or sixty-five miles south of our Arizona line. Its limits comprehended about two thirds each of the territories of New Mexico and Arizona. It was not comparable in violence or extent to the Charleston earthquake.

Apropos of this new volcano, Captain Dutton of the national geological survey, and chief of its volcanic division, is reported as saying that it is a matter of surprise that we have not had more volcanoes in our own territory within the historic period. It is now known that Mount Saint Helena, in Washington territory, was in a state of activity, and sent out large quantities of

lava and ashes as late as in 1843. There have been, beyond doubt, many volcanic outbreaks within the territory now our own not further back than a few centuries.

He added: "I can specify from memory as bearing remarkable evidences of recent occurrence, several localities where violent eruptions have taken place. One is near Fillmore, in Utah; another at the base of Mount Trumbull, on the border of the Grand canyon; a third near Fort Stanton, New Mexico, near the Texas line, and another at Grant Station, on the Atlantic and Pacific railroad, sixty or seventy miles west of Albuquerque. There are many others in southern Arizona.

"I have myself seen a piece of lava in which was imbedded a fragment of Indian pottery, showing that the outflow was subsequent to the occupation of the country by the Indians, and two years ago I visited an extinct volcano in northern California which was so recent that some of the trees killed by the heat had not entirely rotted away."

PREDICTION OF FOG NEAR NEWFOUNDLAND.—The fog-banks which are encountered over, and in the vicinity of, the Banks of Newfoundland constitute the most dreaded feature of trans-Atlantic travel, more particularly during the annual southward movement of the Arctic ice-fields. It is therefore evident that investigations likely to lead to meteorological facts which govern the formation of fog in that region would be of unusual interest to mariners.

In the pursuit of these investigations it is allowable to presume that, with a knowledge of the conditions under which fog is formed, the possibility of foreseeing the development of those conditions would not be remote. The obvious cause of fog formation over the Banks is the intermingling of warm and cold air and water currents. As regards differences in temperature of the water, considered alone, it is not shown that this is the element which contributes to the development of dense fog, and it therefore follows that the air currents constitute the chief auxiliary cause of the more dense formations. The ice-fields necessarily, and very appreciably, lower the temperature of the

air in their vicinity, and the amount of moisture precipitated in the form of fog is governed by the differences in temperature of the air currents which intermingle on their margins. A natural sequence to the approval of this theory would be the conclusion that the greater the differences in temperature of opposing air currents the greater the amount of fog precipitated at their point of contact. With this fact granted we have only to ascertain the causes by which masses of air exhibiting great ranges in temperature may be brought together. As has been stated the ice-fields contribute atmosphere exhibiting low temperatures; for the opposing warm air currents it is necessary to consider the position of the Banks with reference to the relative flow of ocean currents and wind-directions calculated to draw into this locality masses of warm air. The principal source of warmth is found in the waters of the Gulf Stream which flow from the southwestward and pass over the southern portion and to the southward of the Great Banks.

The atmosphere over this warm stream is necessarily more humid and warm than that which overlies the adjacent ocean or the neighboring land, and in this fact we have the second condition requisite to the precipitation of fog atoms. It now remains to determine the general meteorological conditions necessary to cause a continued and large intermingling of the fog engendering masses of air. In this connection it is necessary that the wind-directions whereby the atmosphere is propelled must be considered, as this element constitutes the apparent active agent by means of which it is thought that the probable occurrence and location of fog-banks may be foreseen. As herein shown the region of warm, moist air lies to the southward and southwestward of the Banks of Newfoundland, and, as will be readily seen, the wind-directions necessary to force this air upon the colder air over the ice-fields would be included within the southeast and southwest quadrants. As this region embraces an area traversed by a greater portion of the storm-centres which pass eastward from the continent, and which advance, as a rule, over the Great Lakes and along the Saint Lawrence Valley, it is not unreasonable to conclude that, with a

knowledge of the laws which govern wind-directions in advance of and within storm-areas, the presence of dense fog over the Banks could be determined with a considerable degree of accuracy.

Recent investigations by the Signal Service have verified the above conclusions with reference to the general conditions under which fog has been encountered over the Banks during the past few months, and it is believed that a further study of the subject will result in the possession of knowledge which will prove of practical benefit to maritime interests.—Sergt. E. B. Garriott, in *Monthly Weather Review.*

THE POGONIP:—A curious phenomenon is often witnessed in the mountainous districts of Nevada. Mountaineers call it "pogonip," and describe it as being a sort of frozen fog that appears sometimes in winter, even on the clearest and brightest of days. In an instant the air is filled with floating needles of ice. To breathe the pogonip is death to the lungs. When it comes, people rush to cover.. The Indians dread it as much as the whites. It appears to be caused by the sudden freezing in the air of the moisture which collects about the summits of the high peaks.

THE TWILIGHT PHENOMENA:—The "History and Work of the Warner Observatory," Vol. I, published by the Observatory at Rochester, N. Y., contains the four essays on sky-glows for which prizes were given. These are Dr. Kiesslings, Mr. J. E. Clark's, Mr. H. C. Maine's, and Rev. S. Bishop's, the latter being the article published in our preceding volume. These are valuable contributions to the subject and all of them but the last are illustrated. The publication can probably be obtained from Dr. L. Swift, the director of the observatory.

BALLOON ASCENSION:—The New York *World* and St. Louis *Post-Dispatch* balloon was cut loose from its moorings in St. Louis at 4:26 P. M., June 17. It contained A. F. Moore, Aeronaut; Prof. G. E. Doughty, photographer; Edward Duffy, *World*

correspondent, and Prof. Allen Hazen, of the Signal Service Bureau, and his instruments. They were obliged to descend at 8:15 near Centralia, Ills., the gas having given out. It is reported that Prof. Hazen was satisfied with the scientific results of the ascension.

PERIODICALS, Books and Pamphlets received from June 20 to July 6:—Pilot Chart for July, 1887; Ciel et Terre; Report of the Blue Hill Meteorological Observatory; Annals of Mathematics; Report from the Met. Observatory at Crowborough, Sussex; Phonographic Magazine; State Board of Health Bulletin, Nashville, Tennessee; Canadian Monthly Weather Review; Astronomy and Meteorology; Monthly Reports of the Imperial Observatory, at Rio de Janeiro; Meteorologische Zeitschrift; Science; Foods and Food-Adulterants; School of Mines Quarterly; Report of the Sonn-blick Observatory; Monthly Bulletin of the Italian Meteorological Society; Ocean Currents Contiguous to California; Monthly Weather Review; The Home Farm; Symons Monthly Meteorological Magazine; The Sanitary News; Reports from Nashville; The Sanitarian; The Electrical Review; Report from the Blue Hill Observatory; Report of the Alabama Weather Service; Bulletin of the Colorado Meterological Association; Bulletin of the New England Meteorological Society; Report of the Minnesota Signal Service.

GRAVITY CORRECTION FOR BAROMETERS.

The full text of the action of the International Meteorological Committee at its meeting in Paris in 1885, has just come to hand, and it is gratifying to see that its action, regarding the correction of barometer readings for gravity, has been almost entirely misrepresented, in the abstracts that have thus far seen the light. The resolution adopted was as follows: "The Committee, while finding that, for many questions, it was desirable to introduce the reduction to the latitude of 45° in barometric observations, does not consider itself authorized to make a definite resolution, and therefore postpones the question until the next congress.

In all cases the institutions which are about to adopt this measure from the present time are requested to state at the head of the published tables and charts that the correction for gravity has been applied."

It seems very surprising that a body of eminent, practical meteorologists could have come together and at once, without discussion, decided that this correction was entirely needless, for daily maps at least, and calculated to introduce almost endless labor and hopeless confusion with absolutely no return. The ordinary and essential corrections and reductions for barometer readings are so difficult to learn, to keep track of and often to apply, that many decades will elapse before we can hope to reach such a perfection in these essentials as will make it wise to attempt this farther refinement, and even then the wisdom of spending any labor on so slight a matter might well be questioned. The argument that we cannot learn the poleward gradients in isobars without correcting for gravity is absurd. The total amount of the correction for 9°, north and south, (540 naut. miles) is only $.4^{mm}$, but we do not wish to compare isobars as far apart as that, or at least if isobars of .1 in. are 540 miles from each other, north and south, the gradient, .01 in., would produce no appreciable wind velocity, and the addition of .002 in., the amount of the correction for gravity, would not produce any appreciable effect.

The argument that aneroids and mercurials cannot be compared without this correction seems more plausible at first sight, but it really has no weight whatever. All observations with aneroids are very doubtful, especially is this the case in mid-ocean, but here no correction is needed at all for comparative purposes if all the barometers are aneroid. Now, when the vessel has reached harbor the serious error of the aneroid, ordinarily two three times the total of the gravity correction, can be very easily determined by comparison with a mercurial, and hence a direct comparison can be made between the most important of the aneroid observations and those on land by applying the total correction to the aneroid. But there is a far more important consideration outweighing all these, namely, the fact that many of the better class of vessels carry mercurial barometers. Any

one that is at all acquainted with the action of a mercurial barometer on shore, even under the most careful treatment, will recognize what a very small quantity a mm. (.04 in.) is for daily charts, but when we consider such a barometer carried for hundreds of miles at sea, and continually in motion, we see how hopeless would be the task of making any comparison between a mercurial and aneroid in mid-ocean, so refined as to need a gravity correction. But this is not all, a large share of all barometric observations at sea are made in a rather narrow strip lying about 10° either side of the 45th parallel of latitude. Now, if an aneroid starts from England with a certain correction as compared with a mercurial, and reaches the U. S. with another correction as compared with a mercurial, it becomes quite a simple matter to reduce the aneroid observations to the mercurial standard on either side, and even if the gravity correction were insisted on, in no case would this amount to .02 if the mercurial were not carried more than 10° either side of 45°. The question of .02 in. in an aneroid barometer is so small as compared with the errors inherent in its use, that we need not consider it for a moment. As regards observations on ships going from the equator to higher latitudes, it should be noted that there are relatively very few, and mostly with aneroids which would have no gravity correction, and hence would be directly comparable in mid-ocean; however, these ships would have such long voyages that the errors in the barometers from their lack of fixity, from their change out of a high into a low temperature and *vice versa*, would outweigh two or more times any possible advantage that might arise from a gravity correction. Certainly when we consider the amount of time and labor, the infinitely small benefit to be derived and the great confusion that must inevitably arise, the use of a gravity correction for hundreds of barometers in the interior of a continent hundreds of miles from the sea coast, in order to make at best a doubtful comparison between a few uncertain aneroids and mercurials on the coast, seems the greatest foolishness. Add to this the necessity of correcting thousands of observations of mercurials for gravity, in all latitudes, when the readings themselves are very doubtful, and we reach the climax.

It is very much to be hoped that the full light of day may be shed upon this question before the next International Meteorological Congress meets, and that at that time there may be no uncertain sound as to the impracticability and utter uselessness of this correction. G.

March 25, 1887.

STUDY OF DYNAMICAL METEOROLOGY.

It has been with the greatest interest that the writer has, now and then, noticed remarks in our American journals, which have indicated that quite a number of the younger meteorologists are making the acquaintance of the few writers who have ventured into the field of statical and dynamical meteorology.

In this journal for April, 1885, Mr. Davis brought up the subject of the Effects of the Earth's Rotation, and gave some literature references. It might be well to add to the information in his paper, that the principal point in the method of analysis used by Zöppritz had been previously indicated in the discussion in the Paris Academy about 1860. I think that the first English text-book that gave a thorough analysis of the effects of the earth's rotation on moving bodies was Kerr's Mechanics, published in Glasgow about 1867; this book which is out of print formed an excellent text-book for college students.

In my lectures in 1883–4 at the Signal Service School of Instruction, at Ft. Myer, Va., I used Zöppritz's proof as being most easily understood, and gave the development of the subject about as I had prepared it the year before for the introduction to Professional Paper VIII, Part II.

The student of meteorology must not, however, dwell too long on this preliminary part of the problem of atmospheric motions, for the question has really needed no discussion since Poisson's paper in 1837, but he must take up the application to meteorology, of the general principles of mechanics. The object of this paper is to point out the most important memoirs on this subject, and indicate a general method of preparation for the work.

Prof. Abbe has added a modest foot note to some translations

of meteorological papers in the Smithsonian Report for 1877, and in this note he has given a nearly complete list of the papers published on this problem, up to his time of writing. In the last few years many papers have been added to these, and in 1883 the entire list amounted to sixty or seventy. Many of these papers treat of some one point and are quite short, while some are elaborate memoirs requiring months of study to read them; very few of them are valueless, but one cannot afford the time necessary for reading them all, and so I shall try to indicate the most important ones.*

But before entering upon the study of these papers one must have an idea of their difficulty and the class of knowledge necessary to enable one to understand them.

The following are indispensable: a working knowledge of the differential and integral calculus and the use of partial differential equations; Deschanel's Natural Philosophy or its equivalent, with a copy of Clausius' Theory of Heat (translated by Browne) to use frequently as a reference book; analytic mechanics such as Bartlett's, Poisson's or any such books containing chapters on Fluid Motion, or if one has time to study it out, "Kirchhoff's Mechanik" is perhaps the best one to use, but it is very difficult reading in itself. Some of the papers are extremely difficult in places and most students will not care to do the outside study necessary to make the matter clear; but more will be said of this later.

One does not have to go back more than thirty years for the first important paper on this subject, and most of the rest have been published within the past dozen years. So that the original papers are not confined to a few libraries possessing rare and valuable sets of transactions of societies, but can be obtained through dealers at a moderate outlay of money. F. A. Brockhaus of Leipsig, and Friedländer of Berlin, are good places to

*The writer read many of the papers on this subject, and consulted nearly all of them in 1882-3 while engaged on the preparation of Signal Service Prof. Paper No. VIII, Part II, which is in manuscript at the Signal Office but has not yet been printed. This paper consists of translations of papers by Guldberg and Mohn, Sprung and Oberbeck, with about two-hundred explanatory mathematical and physical notes, and a bibliography.

obtain foreign books, and they could undoubtedly get copies of any of the papers I shall mention.

Ferrel's papers are of the first importance and can readily be obtained, as all of the important ones are among the official publications of the U. S. Coast Survey or the Signal Service; so one has but to interest his congressman in his behalf in order to obtain them.

The most desirable of Ferrel's works are:

The "Meteorological Researches" in the Coast Survey Reports.

Part I, 1877. On the Mechanics and General Motions of the Atmosphere.

Part II, 1880. On Cyclones, Water Spouts and Tornados.

Part III, 1881. On Barometric Hypsometry.

In the Signal Service publications we find:

Professional Paper VIII, Part I. General Motion of the Atmosphere, being a re-print of Ferrel's first mathematical paper.

Professional Paper XII. This contains several minor papers re-published from journals.

Professional Paper XIII. In this paper will be found much original work, but it concerns another topic of meteorological investigation.

Volume II of the Chief Signal Officer's Report for 1885. This is a summation of Ferrel's previous work with some important additions. Professor Ferrel's papers are thoroughly practical; and having determined on what he wishes to accomplish, with the clear insight of an able, original investigator, he selects the necessary analytical methods and applies them at once without preliminary remarks or explanations, and this makes the papers difficult reading.

Ferrel's success seems due to the clearness with which he comprehends the problem to be solved, with all the elements which may affect it, together with a wonderful power of applying mathematical analysis outside of the routine of text-books. Abbe has recently said (in this journal) that Ferrel has proven a veritable Newton in his meteorological work; and it may added that the chief meteorologists of Europe appreciate to the fullest

the importance of his writings. Some years ago when the writer was explaining to a prominent German meteorologist that dynamical meteorology was his (the writer's) topic of present study, the German replied: "Why you can study that at home under Ferrel better than you can in Europe."

It would seem advisable for the student to read some of Ferrel's papers before commencing on the productions of Europeans. In reading them, first take up Signal Service Prof. Paper XII, and then the Coast Survey papers in their order of publication.

After Ferrel's, the next in importance are those of Guldberg and Mohn, and the most valuable of them are the "Etudes sur Les Mouvements de L' Atmosphere."

Premiere Partie Christiania, 1876.

Deuxieme Partie Christiania, 1880.

Part I of these papers will be found not difficult reading, but Part II will require considerable outside reference to text-books. The student will find much aid to the comprehension of Part I, in the more popular exposition of this same subject by the same authors in the *Oesterreichischen Zeitschrift für Meteorologie* for 1877. In these papers, (Etudes, etc.) we have a combination of the meteorological knowledge of Prof. H. Mohn and the mathematical skill of Prof. C. M. Guldberg both of the University of Christiania.

These papers are entirely different from Ferrel's, in that the authors consider the simpler cases first and then lead up to the more general solutions. This makes it easier for the student, and gives him a clearer idea, in the earlier part of his studies, of what the writers are trying to do. Of any real differences in the ideas of Ferrel, and Guldberg and Mohn, we will not speak here—suffice it to say that they have given us the first memoirs that treat of the atmospheric motions from a truly analytical point of view. These three writers are in, ought we say form, the front rank of theoretical meteorological investigators and so their writings require the most attention. As, however, the writings of Guldberg and Mohn are so little known in this country, the present writer hopes to give an extended notice of their work to the readers of this journal at another time.

Drs. Hann of Vienna, and Sprung of Hamburg now at Berlin, have done much to further the study of this new branch of meteorology, the former by his criticisms and comparisons of the different theories, and the latter by his numerous reviews, original contributions, and his new text-book.

In the "Annalen der Physik und Chemie" for 1882, Prof. Oberbeck of the University at Halle published a paper of twenty pages, with the title "Ueber die Bewegungen der Luft an der Erdoberfläche." His paper may be read as a continuation of those of Guldberg and Mohn, and it is gratifying to see how by the use of the latest mathematical analysis he arrives at conclusions which strengthen our acceptance of the results furnished by those writers and Ferrel. Portions of Oberbeck's paper are difficult reading and the present writer found "Kirchhoff's Mechanik" an indispensable aid in studying it. The further application of "Vortex Motion" in the direction of Oberbeck's investigations of cyclonic phenomena offers a promising field to the advanced mathematician.

Marchi has given a paper on "Ricerche sulla teoria matematica dei venti," in the *Annali di Meteorologia*, Part I, 1882, which seems to be an important contribution (the present writer has only seen the review of it by Margules in the XIX Vol. *Oester. Zeit. f. Meteor.* and extracts in Sprungs Meteorologie), but it will probably be little known in the original in this country.

It is also understood that a Japanese has very recently published a paper (in German) which treats of this subject in an elaborate manner.

Dr. Fuiger, of Vienna, gave us an elegant analysis of the question of the influence of the earth's rotation, in his two papers published in the proceedings of the Vienna Academy. They have the title:

I. "Uber den Enifluss der Erdrotation auf die parallel zur sphäroidalen Erdoberfläche in beliebigen Bahnen vor sich gehenden Bewegungen, insbesondere auf die Strömungen der Flüsse und Winde. Juni, 1877."

II. "Uber den Einfluss der Rotation des Erdsphäroids auf

terrestrische Bewegungen, insbesondere auf Meeres—und Windströmungen. Mai, 1880."

Finger's method deserves particular attention, but his conclusions are those of a mathematician rather than those of a meteorologist. His papers are, therefore, more valuable to the theoretician than to the practical meteorologist.

While the two treatises on meteorology (by Sprung and Ferrel) that have recently appeared, contain as much of the theory and application as will satisfy the college and university student, yet the writer finds that they do not lessen the value of the original memoirs that have been mentioned here, and those who wish to study the subject in detail will still be obliged to consult the original papers, and cannot substitute for them the more readily accessible text-books. On the other hand, however, these latter contain much that will aid one in comprehending the former.

Although much has now been written on these subjects, and the views of some writers are being adopted, it must be borne in mind that many of the theories are far from being complete and will be subject to much revision and in some cases to total rejection, by future workers. It is on account of this uncertainty as to what to accept and what to reject, that the putting of the present knowledge into shape for college and general students has been retarded; because the student cannot be expected to have mature judgment concerning theories and must be given only that which is known to be true, or at least is generally accepted.

To a subject like this, which the members of the leading Academies of Science treat with great caution, the younger men cannot hope to add much new thought, but this need not deter us from trying to follow the leaders in the work.

FRANK WALDO.

Cincinnati, Ohio.

RECENT ADVANCES IN METEOROLOGY.*

Since the publication of Prof. Loomis' *Treatise on Meteorology* twenty years ago, no text-book of value covering this branch of science has been issued by the American press.

* Recent Advances in Meteorology by Wm. Ferrel, Washington, 1886.

During this period inductive meteorology has made great advances, many workers throughout the world utilizing the large mass of data that has been gathered by national meteorological services. It is within this period, also, that deductive meteorology, or the mathematical study of the motions of the atmosphere, has been developed by a few writers, among whom Prof. Ferrel stands as a leader.

On the Continent, the new meteorology has been fully collated by Mohn, Hann, Sprung and Van Bebber, and, in England, Scott has published a very complete descriptive text-book, although too elementary to contain the higher meteorology. A systematic treatise covering this field has long been needed for classes in American colleges. The present work by Prof. Ferrel covers that portion of the new meteorology which he has done so much to develop, but is not in any sense a complete treatise on meteorology. The recent development of the science, however, has been such that even an approximately full treatise on meteorology can no longer be comprised within the limits of a single volume.

The work is divided into seven chapters, as follows:

I. The constitution and physical properties of the atmosphere.
II. Temperature of the atmosphere and earth's surface.
III. The general motions and pressure of the atmosphere.
IV. Cyclones.
V. Tornadoes.
VI. Meteorological observations and their reductions.
VII. Ocean currents and their meteorological effects.

The present article will be confined to a review of the first four sections of Chapter I, with special reference to class use.

The first section treats of the composition of the atmosphere, and presents very fully the results of the best analyses, giving the relative proportion of the various constituents, and, for carbonic acid, ammonia, and ozone, their seasonal variation.

The second section develops with great care and very completely the principles and laws of atmospheric pressure. The section is entitled "pressure *and weight* of the atmosphere," but the apparent tautology disappears in the light of Prof.

Ferrel's definition of weight, wherein the weight of a body is made the measure of its mass. It is most surprising to find this usage adopted by a mathematician and physicist. According to the best physical terminology the *weight* of a body is the effect of the force of gravitation upon it, and is to be measured by the mass and the acceleration conjointly. In engineering, or in common usage, no difficulty is experienced by neglecting the small variations in gravity and assuming the weight proportional, or, if the proper units be used, equal to the mass; but in a scientific text-book, where the discussion of the variations of gravity is an important feature, the use of the words mass and weight as equivalent, necessitating as it does a variable unit of force, is most confusing. In the interest of clearness of thought, the ideas of mass and weight must be kept distinct.

After this definition of weight, the section contains an elegant derivation of the hypsometric formula. The equations, however, are marred by a large number of typographical errors, and in occasional instances the assumptions involved in the solution lack explicit statement. For example, the definition of l, page 22, would be rendered much clearer if the implied assumption of uniform gravity were expressed, so as to read "the height of a column of gas of uniform density which, *under the assumption of uniform gravity*, has the same weight," etc. This would aid in understanding the paragraph that follows, lines 1 to 8, page 23, which, apparently, is an incomplete modification of an earlier and clearer draft, and does not correspond with the preceding definition of l. The paragraph should state, in substance, that in the actual atmosphere, where the assumption of uniform gravity does not obtain, the value of l is not strictly the height of a homogeneous atmosphere, for the mercury and air have not the same *pressure* since different parts of the air column are acted on by forces of gravity varying with the height, while that acting on the mercury is sensibly the same for all parts; the height of a column of air of the same *pressure* would be a little greater. As it stands, the paragraph is difficult to interpret, the more because of the

unfortunate use of *mass* and *weight* as equivalent, at a point where the effect of the variation of gravity is the subject of explanation.

In the frequent use of *tension* where the author means *pressure*, the book fails again to conform to the standard set by the Scottish school of physical precision.

A most valuable feature of this section, because it is a subject not often treated, is a presentation of the results of experiments on the deviations of the law of Boyle and Mariotte, and that of Charles, the uncertainty as to whether the former holds good for very low pressures, and the consequent limitations in the application of the hypsometric formula.

Section iii treats of diffusion in the atmosphere, and section iv of the dynamic heating and cooling of the air, and the conditions of stable and unstable equilibrium. In the latter section the thermodynamic equations, giving the discriminating condition of equilibrium, are developed from elementary definitions and principles, but at several points the equations do not receive sufficient explanation to be readily understood without a supplementary knowledge of thermodynamics. For example, in equation (67), with no clear statement of authority, $C_v\, dT$, the heat required to raise the temperature of a unit mass of air through dT degrees, when the volume is constant, is substituted for the corresponding amount of heat required to do the internal work in raising the temperature dT degrees under constant pressure. A statement that the experiments of Joule and Thomson show that the internal energy of a gas is a function of its temperature alone, would furnish the necessary explanation.

Similarly, the use of equation (70) to obtain the equation in line 21, page 47, requires a change in the sign of dQ, arising from the circumstances of the problem, but no explanation of this very important feature is given, and the student is prevented from discovering the peculiarity, by the fact that the new equation is erroneously printed with the same sign as equation (70).

In the formulæ on the same page (47) the letter e is used in two senses, in one case representing the tension of aqueous vapor, and in the other the *relative* tension in terms of the total atmospheric pressure.

The formulæ resulting from Prof. Ferrel's presentation give the criterion for the condition of stable or unstable equilibrium for any portion of the atmosphere, under the assumption that an ascending current of saturated air receives no heat except from the latent heat of condensation. In the actual atmosphere, however, this assumption is generally very far from true, for cloud, condensed from an ascending current of air, absorbs at its upper surface all the solar heat which, in a clear sky, is transmitted through the air and heats the earth. The ascensional power of saturated air, therefore, must generally be much greater than that given by Prof. Ferrel, as deduced from the mathematical formulæ.

As an aid to students, the following list of the more important typographical errors is appended.

Page 21, lines 18 and 19,	$V e^1$	should	be	$v e^1$
" equation (25),	${}_0\rho$	"	"	ρ_0
Page 22, equation (26),	P	"	"	P_0
" line 9,	v_2	"	"	v'_2
" equation (27′),	v'_1	"	"	v'_2
" line 18,	v_1	"	"	v'_2
" line 5 from bottom,	*and*	"	"	*of*
Page 23, equations (30) and (31),	r	"	"	r'
" line 30	(27)	"	"	(28)
" equation, line 31,	$\frac{q}{lc}$	"	"	$-\frac{1}{qlc}$
" equation (32)	$\frac{q}{lc}$	"	"	$\frac{1}{qlc}$
" equation (33)	e *and* r	"	"	ϵ' *and* r'
Page 25, line 4 from bottom	ρ_0	"	"	ρ'_0
Page 26, equation (43)	e	"	"	e'
" equation (43)	$\tau + 32$	"	"	$\tau - 32$
Page 28, equation (48)	τ'	"	"	τ
" equation (48)	6604463	"	"	6364463
" lines 8 and 24, and equation (49)	0.0000003	"	"	0.0000016
" line 23.	0.51493	"	"	0.51703
" line 23.	Table VI	"	"	Table IV.
" line 24,	Table IV	"	"	Table VI.
" line 25,	Tables I and IV	"	"	Table I.

" line 26,	0.51493	"	"	4.78189.
Page 30, equation (56′)	$(1 + e)$	"	"	$(1 + .378\,e)$
" line 13	(62)	"	"	(58)
" line 13	t	"	"	τ
Page 31, line 1	φ	"	"	ρ
" line 22	*number*	"	"	*member*
Page 33, examples (*a*)	$\frac{.76 \times 13.596}{.00129278}$	"	"	$\frac{.76 \times 13.596}{.00129278 \times .0692}$

Page 47, equation, line 21,

$$\frac{C\,d\tau}{ART} - \frac{1}{ART}(\ )$$

should be

$$\frac{C\,d\tau}{ART} + \frac{1}{ART}(\ )$$

Page 48, line 1, *number* should be *member*.

GEORGE E. CURTIS.

SELECTION.

POPULAR ERRORS IN METEOROLOGY.

[CONTINUED.]

Many efforts have been made in this country to show that the destruction of our forests has affected our climate, and many instances are quoted to prove that the growth of forests on our treeless prairies has already materially modified the local climate—to neither of these views can I give my assent, and still less to the theory advocated by some that the extension of telegraph and railroad lines has so affected the distribution of the electricity that more rain now falls in some localities than before. Of all such propositions, the weak point consists in the fact that we have not enough observations of rainfall and temperature properly comparable with each other to justify any conclusion whatever. So variable is our climate that a change of temperature of several degrees Fahrenheit, or a change of five per cent. in the average rainfall, could only be decided by comparing the average of 100 years of observation with the

average of another 100 years taken before, or afterwards, under precisely similar circumstances. The mistakes in this respect have often arisen from an overweening confidence in one's memory. The oldest inhabitant confidently states that this is the coldest winter he ever knew; the leading newspaper reporter interviews him, and there appears a double-leaded article, with heavy head-lines: "Coldest Winter on Record. Decided Secular Changes in the Climate. Interesting Reminiscences of the Olden Time." The children and everybody read it, and become firmly convinced that the climate has changed, whereas the whole thing is based on the fallible memory of one man and the ready business talent of another, and the truth is that, so far as our records go, whether of rainfall, or temperature, or animal or plant life, all things remain as they were in the days of our fathers; at least, so far as the atmosphere is concerned; a proviso that I insert because we are gradually getting proof of the occurrence of local changes of climate, consequent upon slow changes in elevation above sea-level.

If I have touched upon a few wide-spread popular misconceptions in regard to my science, I have still to take up a long list of questions frequently put to me and showing general, if not popular, errors widespread among this most intelligent nation; for instance, "Is the whirling-storm called hurricane, cyclone or tornado, caused by the friction between two great horizontal currents of air like the little whirls we see immediately behind a bridge pier in the middle of a river?" to which I answer, No! That was Dove's theory, but the meteorologists of to-day ascribe the tornado and cyclone to an uprush of air under one or more clouds, and the whirling is inevitable when the lower air rushes together from all sides to fill the place of that which has ascended. And here I would call attention to an erroneous use of the word cyclone confined to some of the newspapers in this country, and which will, I hope, not be perpetuated, since many of the most reputable papers have already returned to a proper use of the word; the terms cyclone and hurricane should be applied to large storms only, and the term tornado be restricted to those small and violent storms in which

the up-draught through or around a central nearly vertical cloud or spout is the most prominent feature next after the terribly violent and destructive winds.

Again: among my questions is this:

"What is the special cause of the regular equinoctial storm?"

I am sorry to say that I know no "regular equinoctial." An old writer says: "Ye wind hath been noticed to be very tempestuous at ye time of ye equinoxes." All over the world it is a favorite habit among mankind to find a name, or a proverb, to suit every striking weather item: thus we have a Sunday rain, a Michaelmas thaw, an equinox storm, a dog-day heat, etc. These names, however, are only names, and prove nothing as to the reasons underlying the phenomena. With the changes of the sun's position and the consequent distribution of hot and cold air there come alike to old England and New England months of stormy weather—the storm that appears next before or after the 21st of March, or the 21st of September, is dubbed the equinoctial of that year, but the name does not give the storm any other peculiarity. The frequency of storms is about the same for several successive weeks and one is as likely to occur on any other date as the date of the equinox.

Again: why is there less rainfall caught in guages high above the ground than in those on the ground? Do the drops grow as they descend?

The drops rarely grow after they have so nearly reached the ground, although they do grow as they descend through clouds of fog.

There is really the same amount of rainfall at 100 or fifty feet altitude as on the ground; the fault is in our rain-gauge, which is exposed to stronger winds when set high up, and to almost no wind when flush with the ground. The stronger winds deflected around the gauge carry the drops to one side, and hence the higher gauge catches less than the lower one.

Among the experiments elucidating this principle are some made on your shot-tower, by Bache, fifty years ago, that have lately come to be more fully appreciated.

Again: why is it colder on a mountain top, near the sun?

It is a very common error to forget that everything—our own well-clothed bodies included—is giving out heat rapidly by radiation, and that the maintenance of any pleasant temperature is due to the fact that the loss by our own radiation is equalized by an equal gain through the absorption of the radiation from other substances. But this latter is wanting in the case of objects on the summits of mountains, which, therefore, cool rapidly and stay so.

Some one asks: "Why do all signs fail in dry weather?" and "Why are Signal Service predictions of rain specially erroneous during droughts?" There are probably several reasons for this, some meteorological, some subjective. During droughts, one generally sees clouds forming during the morning hours, as the ground becomes warmer and warmer, showing that there is moisture in the air, but that it is slightly less than needed to form rain. In this delicate balance between conditions favorable and unfavorable to rain, the predictor needs, but has not, observations of the conditions prevailing in the atmosphere at large, as well as those prevailing at the surface of the earth. The absence of the necessary knowledge, therefore, increases the chance of an erroneous prediction. There is, moreover, a slightly subjective or personal consideration, namely, being aware of the existence of the drought and the great desire for rain, he is liable to yield to the desire we all feel to say something pleasant, or to predict that which will be most agreeable if it occurs; thus, the hope that it may rain, colors his predictions, so that between the two phrases, "fair weather" and "fair weather, possibly followed by light local rains," he is likely to adopt the latter as his prediction. The farmer who receives the latter sees the clouds gathering, and when the local thunderstorm passes by leaving him dry, but wetting some distant region, in his disappointment he calls the whole a failure; whereas the occurrence of even that slight local rain in a limited region has been for the Signal Service predictor a complete verification, but the clamor of the thousands who did not receive the rain, overpowers the quiet rejoicing of the hundreds who did receive it.

Finally, it may be considered as a popular error that the people should *expect* the Army Signal Office to make perfectly correct local weather predictions thirty-six hours in advance for their benefit. That this is expected, we know by the grumbles we hear when a failure is announced. There even seems to be a growing disposition to look to the Signal Office for general weather or climatic predictions several weeks in advance of the season. Such predictions have been made in a few other countries, but when we consider the special methods that have been invented for that purpose, you will realize how very unsatisfactory such predictions may become. Thus, suppose we have for Philadelphia 100 years of daily weather records, and find that January 1st has during these 100 years been rainy ten times, snowy twenty times, fair—namely, neither rain nor snow—seventy times, then we should naturally predict for next New Year's Day fair weather, as the chances are in favor of that. But, after all, the favorable probability is too slight to be of much value. In the present state of our knowledge, these predictions will probably not be verified one-fourth of the time, and a person will do just as well to regulate his business without them. This latter conclusion I have heard sometimes made in a carping way with reference even to the well-known daily weather indications of the Signal Office; but this, I am sure, is altogether too sweeping, and nothing could be more erroneous than to condemn the great work of that office because of an occasional or even a frequent failure, since by general consent, and by actual numerical data made up from the returns of hundreds of independent observers throughout the country, we know that those who from day to day regulate their business by its predictions find great profit therein.

However, I am by no means sure that detailed long range weather predictions would be very agreeable or profitable—"sufficient unto the day is the evil thereof." What would you do, my hearer, if you knew exactly what the weather is to be hour by hour for this next coming year. Would you be able to pick out the best day on which to plough, or sew, or reap? On *this* day the prediction gives you fair weather; will you plant at

once, knowing that the prediction says heavy frosts on *this* day three weeks later, just in time to kill your young crops? Will you reap to-day because the predicted weather is highly favorable, knowing that before half of that crop can be gathered into your barns the predicted hail-storm will be upon you? As nearly as I can see, he who should perfectly foreknow the weather would find himself at every step confronted by some approaching dilemma, some inevitable disappointment or loss; and shrinking, as we all do, from such events, he would sit down in despair and do nothing at all. In a general way, it is true of the weather, as of anything else, that an All-Merciful Father hides the future from us so that we, in our ignorance and helplessness, may labor on, full of hope that things may not turn out so bad after all.

And yet, so confident am I of the great future development of man and of science, and so clearly do I see the wise provision by which *everywhere in Nature we find the right thing, in the right place, at the right time*, that I dare predict to-night *the time will come* when men shall be able to endure and utilize detailed weather predictions for months and years in advance; and when that time comes the prophet and his predictions will be on hand.

CLEVELAND ABBE.

RECENT LITERATURE OF THE RAINBAND.*

The paper of Mr. Rankin, describing his rainband observation on Ben Nevis, is so important, and brings before us so forcibly the value of the spectroscope as an instrument of meteorological research, that I may be excused if I offer a few remarks on what has been done in this direction by other observers.

Our Journal records the rise of rainband spectroscopy, and we have had opportunities of hearing the eloquent dissertations of Professor Piazzi Smyth on this subject, which is so dear to him, and for which he has done so much. It is unnecessary, therefore, to refer to the early history of the rainband, and my

* Scottish Meteorological Society, April. 1886.

remarks will be chiefly confined to what has been written during the last five years. The variability of the water-vapour lines in the spectrum was recognized from the beginning of spectroscopic study. Mr. J. P. Maclear in 1872 (*Nature*, v. 341) drew attention to it; and although he did not see its use in predicting rain, he strongly urged the importance of conducting spectroscopic observations as an aid to meteorologists in understanding the changes of hygrometrical conditions. In 1874, also, MM. Crocé-Spinelli and Sivel (*Comptes Rendus*, lxxviii. 946) observed the water-vapour bands about D during a balloon ascent, and found that, as M. Janssen had predicted, they got fainter as the height above the earth's surface increased. At 20,000 feet the rainband vanished, and the solar lines E and F increased in intensity; a result confirmed by the decreased strength of rainband relatively to solar lines seen by Mr. Rankin on Ben Nevis.

Next to Professor Smyth's writings, the most popular and successful paper has been Mr. J. Rand Capron's 'Plea for the Rainband,' published in *Symon's Meteorological Magazine* in December, 1881, shortly thereafter reprinted and widely circulated in pamphlet form; and now, along with a paper, 'The Rainband Vindicated,' and additional matter, published as a little book.* In this last edition Mr. Capron recalls attention to a paper in the *Meteorological Magazine* for 1869 (presumably by the editor), which, after describing the solar spectrum, concludes with the words, 'No one can tell what secrets lie hid in these atmospheric lines, but to us it seems that by their careful and systematic observation the "Message from the Stars," which has taught us so much, may be rivalled in practical importance by a Message from the Sky.' This vague shadowing, interesting though it is, in no wise invalidates the claim of Professor Smyth to the entire honor of inventing the use of the spectroscope in weather predictions.

Shortly after the appearance of Mr. Capron's first paper, the Signal Service of the United States took up the matter; and,

* Stanford, 1886.

after a series of experimental trials, Mr. Winslow Upton, in 1883, produced a valuable 'Note on the Use of the Spectroscope in Meteorological Observations,' which was published by the War Department. Copies of this paper and spectroscopes were distributed amongst various of the government observers, but the results, I am informed, were very unequal. Some got into the way of using the spectroscope at once, and found its indications of considerable predictive value; others could never see the rainband satisfactorily. This was due, in part at least, to the instrument employed, for one of the unsuccessful observers was able to distinguish the rainband easily in a spectroscope by a different maker. While the Signal Service is doing some important work, meteorological spectroscopy in America owes its greatest advance to Professor C. S. Cook, who has effectually solved the problem of measuring the rainband. The apparatus (described in *Science*, ii. pp. 488–491) consists of a direct vision spectroscope, which splits D and shows the rainband as separate lines, mounted on a graduated alt-azimuth stand, and fitted with a measuring arrangement. This is a fine spider thread or platinum wire fixed in a sliding frame in the tube of the instrument, and capable of being moved to and fro by a delicate micrometer screw. When the wire is moved slightly out of focus a double image of it appears, which becomes wider and less distinct as the distance increases. To measure the principal line of the rainband, the micrometer screw is turned until the image of the wire is just as intense as the line, and the number opposite the index on the divided head of the screw is read. This number denotes the strength of the rainband. Professor Cook can distinguish forty shades of difference in intensity; and of course his system of measurement is independent of the uncertainty connected with a mental scale, some form of which all other meteorologists had been obliged to employ, however reluctantly. Professor Cook, by directing his spectroscope in different directions and at various altitudes, was able to map out invisible masses of cloud material, to watch their movements, measure their increase until visible cloud and then rain began to form, or their gradual diminution by rise of

temperature or mixture with the surrounding drier air. He has found extraordinary differences in the distribution of aqueous vapour when the sky appears absolutely homogeneous to the eye, both while it is all blue and bright, and when there is a close pall of cloud. His instrument is for the observatory; and while its indications can lay claim to great scientific exactness, it is unsuited, alike by its size, cost, and delicacy, for use in the semi-popular way in which small spectroscopes can be so readily employed.

Mr. F. W. Cory published in 1884 a little book,* *How to Foretell the Weather with the Pocket Spectroscope.* It contains much that is suggestive of further advance; and by way of appendix, the correspondence in the *Times* during September, 1882, on the subject of predictions by the rainband, is reprinted.

In January, 1883, I read a paper to the Royal Society of Edinburgh (*Proceedings*, xii. pp. 47–56) on 'Observations of the Rainband from June, 1882, to January, 1883,' and in September of that year expanded it into a popular pamphlet of thirty-eight pages, which was published by Hilger.

On January 1st, 1884, the astronomical and meteorological journal, *Ciel et Terre*, published in Brussels, contained an article by Captain C. Peny, entitled 'La borne gnomo-météorologique de l'école militaire,' and describing a number of meteorological instruments, amongst others the rainband spectroscope, to which six out of thirteen pages were devoted.

M. G. Dallet, writing 'De l'usage du spectroscope en météorologie,' in the *Revue Scientifique*, a Paris paper of popular science, for September, 1884, described the meteorological use of the spectroscope, quoting freely from Captain Peny's article, and copying from him a 'little table' of rainband predictions. He referred also to the work of Professor Piazzi Smyth, Mr. Upton, and Mr. Rand Capron. M. Dallet had evidently not seen my little book, which did not surprise me; but from his article I heard for the first time of Captain Peny's contribu-

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* London: Chatto & Windus.

tion to rainband literature; and I turned to *Ciel et Terre* with the greater interest, because it appeared that the Belgian observer had hit upon the same method of measuring the rainband as I employed, viz., comparison with the solar lines. Captain Peny's article proved more interesting than I had expected. There was no indication by quotation marks or references to any other worker that it was not entirely original; at the end, indeed, 'les meileurs experimentateurs' are cited as recommending certain rules for observing, but that was all. Yet, with the exception of the description of a spectroscope, which differed from mine, there was not a line which had not been translated from my pamphlet, 'little table' and all, although in it, for some unknown reason, the solar line *b* is called *i*. It formed, in fact. a very good abstract of my paper, which must have been read with much attention, and from which there is only one statement not directly derived,—the erroneous statement that the spectral lines D, E, F, etc., are 'for the most part due to absorption of light by the vapour of water in the atmosphere.'

The editor of the Belgian paper is not to blame; as far as he can, he is particular about acknowledging the source of his material, as a 'note' in the number for October, 1884, distinctly states. Here the editor speaks severely of several journals which had reprinted some of his articles as original, and concludes, 'It is necessary in these matters to have the spirit of the precept, "Render unto Cæsar the things that are Cæsar's," always present with one. That we follow it with the greatest care may be readily seen by the number of references at the foot of our pages.'

I must apologize for dwelling on a personal matter, especially as so long a time has elapsed since Captain Peny forgot to hold me responsible for my views, but I thought it advisable to take this opportunity of setting the matter right. I might have done so earlier, but various things came in the way.

The absorption spectrum of the atmosphere has been studied in France more as a branch of physics than as a department of meteorology; and the work of MM. Janssen, Cornu, and Egoroff

is of the greatest importance in this respect, comparing with the detailed spectroscopic researches of Professor Piazzi Smyth and others in this country.

I am not acquainted with many rainband observations made on the Continent. The subject appears not to have received so much attention there as in Great Britain and America; but from such records of work as I have seen, it is evident that good results have been obtained. Mr. J. Aitkin has informed me that in the south of France rain predictions by the rainband can be relied upon to a much greater extent than in this climate of changes.

Considering Great Britain and the United States alone, there can be no doubt of the fact that the rainband spectroscope has passed through its stage of scientific toyhood — marked by numerous contradictory letters to scientific and non-scientific papers—and that it is taking its rightful position as an aid to meteorology, and as the best means by which a single observer can ascertain the probability of rain falling in a given short period.

It is claimed by some observers (Cory, p. 32, and Rand Capron, pp. 13 and 22), that the appearance of the spectral colours gives a clue to the amount of ozone in the air; but the difficulty of detecting and estimating this little understood, though perhaps too much respected, constituent of our atmosphere, necessarily prevents the speculation from being verified.

Considerable difference of opinion exists as to the best instrument to use. Personal liking has undoubtedly a great deal to do with the choice, for after an observer has become thoroughly acquainted with a particular spectroscope, he is naturally reluctant to change it. Mr. Capron and others recommend that Browning's 'Rainband Spectroscope' should be employed as a standard. I prefer Hilger's instruments, and I believe that the smallest size is most suitable for ordinary observers. It seems to me that the interpretation of the indications of a large instrument, showing the rainband detached from the D-line, must be accepted with much reserve, unless some sort of mechanical measure is employed, such as Professor Cook's micrometer, or Mr. Rand Capron's modification of my didymium wedge.

At best, rainband indications are uncertain, because of the rapidity with which changes in the atmospheric conditions take place; and although the spectroscope has been shown by many observers to give 80 per cent. of correct predictions of rain or no rain in a given time, results of great scientific value can only be expected, when, as at Ben Nevis, it is combined with a complete series of hourly meteorological observations.

Following is a list of most of the important papers on rainband spectroscopy which have been published:—

Published before 1882, chiefly by C. Piazzi Smyth—
Edinburgh Astronomical Transactions, xiv. p. 29, appendix.
Scottish Meteorological Journal, n. s. v. 84-87, 193; li., lii., lv.
Nature, xii. 231, 252, 366; xiv. 9; xvi. 389; xxii. 194; xxv. 551.

1882. J. Rand Capron—'A Plea for the Rainband,' *Observatory*, 1882, 42-47, 71-77; also in pamphlet form.

" J. T. D. Donnelly—'A Meteorological Spectroscope,' *Nature*, xxvi. 501.

" C. Piazzi Smyth—'Spectroscopic Weather Discussions,' *Nature*, xxvi. 551-554; also in pamphlet form.

" R. Abercrombie—'The Spectroscope and Weather Forecasting,' *Nature*, xxvi. 572-573.

1883. H. R. Mill—'Observations of the Rainband from June, 1882, to January, 1883,' *Proc. R. S. E*, xii. 47-56.

" F. W. Cory—'The Spectroscope as an Aid to Forecasting,' *Quart. Jour. Met. Soc.*, ix. 234-239.

" H. R. Mill—'The Rainband: How to Observe it, and What to Expect from it.' London: Hilger.

" C. S. Cook—'The Use of the Spectrsocope in Meteorology,' *Science*, ii. 488-491.

" W. Upton—'The Use of the Spectroscope in Meteorological Observations,' *U. S. Signal Service Notes*, No. 4.

" C. Piazzi Smyth—'Rainband Spectroscopy attacked again,' *Nature*, xxix, 525.

" F. W. Cory—'The Hygro-spectroscope,' *Science Monthly*, Dec.,1883.

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HUGH ROBERT MILL.

TEMPERATURES AT WHICH DIFFERENCES BETWEEN MERCURIAL AND AIR THERMOMETERS ARE GREATEST.*

Glass and mercury do not expand uniformly. An increase in temperature of one degree at one hundred degrees causes greater changes of volume than the same increase at zero. (In all references here to degrees and temperatures the centigrade scale is to be understood.) Normal mercurial thermometers, when corrected for their various errors of construction, differ among themselves and also from the air-thermometer.

At 40° the mercurial thermometer reads about 0.°2 higher than the air-thermometer. At — 38.°8, the melting point of mercury, it reads about 0.°2 lower. The quality of mercury in a thermometer has an influence on its reading. A thermometer containing $\frac{1}{10000}$ of lead in the mercury will read 0.°5 lower at 50° than if the mercury is pure. [H. J. Green.]

Comparisons have been made at the Signal Office between an air-thermometer and a number of mercurials. Some deductions have been made from the results of this work as to the temperatures at which the differences between the two thermometers are greatest. From the same results there have also been derived values of the coefficients of expansion of glass dependent on the second and third powers of the temperatures. It is to these I wish to call your attention.

The air-thermometer used was of the kind that measures temperatures by the varying pressure of a quantity of air kept at a constant volume. Five Tounelot mercurial thermometers were compared with this air-thermometer at temperatures from 0° to 55°. Two Baudin thermometers were compared with it from 0° to — 38.°8.

* Thomas Russell in the *Bulletin of the Phil. Soc.* of Washington, Vol. IX, pp. 25-32.

The freezing points of mercurial thermometers rise with age. A few days after a thermometer is filled this rise may amount to a whole degree. In a year after that it may rise an additional five-tenths of a degree; with succeeding years the change is less and less.

When a thermometer is raised to a high temperature its freezing point is depressed. The average depression for 100° is about 0.°2. On raising to a temperature lower than 100° the freezing point is also depressed, but not so much. For 50° the depression is about 0.°05. For temperatures as high as 100° the depressions are about proportional to the squares of the temperatures by which they are produced.

The cause of these changes of freezing point is in the nature of the glass. The mercury in the thermometer has nothing to do with them; neither has the atmospheric pressure.

The amount of the changes depends on the composition of the glass in the thermometer-bulb. It has been recently ascertained by H. F. Wiebe that the change is greatest for glass containing equal quantities of potash and soda. A thermometer made of a variety of glass containing 14 per cent. of potash, 14 per cent. of soda, the remainder silica and oxide of lead, was found to have its freezing point depressed 0.°84 on raising it to 100°. Thermometers in which the potash or soda in the glass was replaced by lime were found to have the freezing points depressed only 0.°07 ror the temperature of 100°.

To produce the maximum depression of freezing point peculiar to any temperature requires that the thermometer be kept at that temperature for a certain length of time. For a temperature of 100° a half hour suffices; for 50° two hours are required.

If the thermometer is kept at 100° longer than half an hour the depressed freezing point after that time begins to rise. If continued at the higher temperature for two weeks the freezing point at the end of that time will be found to have risen about one degree. This fact is taken advantage of by some makers of thermometers to produce an instrument whose freezing point will vary but little in years subsequent to its manufacture.

The depression of freezing point produced by high temperature is only temporary. The thermometer in the course of time regains the reading of its freezing point corresponding to ordinary temperatures. The more quickly the depression is produced the more slowly the reading is regained.

After a thermometer has been subjected to a temperature of 100° it will regain its ordinary freezing point reading in one month. The change in the first part of this period is much more rapid than towards the end. To recover the depression caused by 50° requires only two days. The older a thermometer the more quickly it gains its freezing point corresponding to ordinary temperatures. An instrument forty years old will regain its freezing point after exposure to 100° in one week while an instrument three years old requires a month.

The more alternations of temperature a thermometer is subjected to the more quickly its freezing point rises.

A thermometer subjected to a very high temperature, as 350°, will have its freezing point raised from 12° to 20°. This rise is not due to softness of the glass at the high temperature and a consequent diminution in the volume of the bulb by the atmospheric pressure. This is shown by experiments with weight-thermometers. In these the tubes are open to the pressure of the air and there is as much pressure inside as outside the bulb.

As heating to 100° depresses the freezing point while heating to 350° raises it there must be some intermediate temperature for which there is no change. This point is usually at the temperature of about 160° to 180°, but varies widely with thermometers made of different kinds of glass.

When a thermometer is subjected to a very low temperature a temporary rise in its freezing point is produced. To produce an appreciable rise requires a long-continued exposure. After being kept twenty-four hours at — 30° the freezing point is found to be about 0.05° higher than at first.

One hundred degrees on the centigrade scale is taken as the temperature of steam from pure water boiling under a normal barometric pressure equal to 760 mm. of mercury. A variation of 1 mm. in the pressure will change the temperature 0.04°.

Zero is taken as the temperature at which pure ice melts when subject to an atmosphere of pressure. An increase of a whole atmosphere lowers the temperature of the melting point of ice 0.008°. This is to be distinguished from the effect of an atmosphere of pressure on the reading of a thermometer; by compressing the bulb it causes the thermometer to read about 0.°2 higher than if there was no pressure.

The fundamental distance on a normal thermometer is taken as the reading it would have at a true temperature of exactly 100° minus the reading of its depressed freezing point. This, which should be exactly one hundred degrees, rarely is so. When the fundamental distance is taken in this way it is invariable with age. It is the same forty years after the thermometer is made as four hours after, provided the thermometer is kept at ordinary temperatures. The fundamental distance is not invariable when the raised freezing point is used in forming it instead of the depressed freezing point. In this case there is a constant diminution with age as the raised freezing point rises more rapidly than the boiling point. There is not uniformity of practice in the matter of forming the fundamental distance, but it is greatly to be desired.

Heating a thermometer to 350° causes a permanent increase in its fundamental distance between depressed freezing point and boiling, varying from 0.°4 to 0.°9. An increase of 0.°4 in the fundamental distance corresponds to a decrease of $\frac{1}{50}$ part in the coefficient of expansion of the glass.

The total correction of a mercurial normal thermometer for errors in its construction is composed of three parts:

1st. The correction for erroneous fundamental distance. For any temperature this is a proportional part of the difference between the fundamental distance and 100°.

2nd. The calibration correction. This is the correction to the scale marks considered as subdividing the capacity of the tube from 0° to 100° into one hundred equal parts. It involves variations in the bore of the tube as well as irregularities in the placing of the marks.

3rd. The correction at freezing point. This is the amount the

thermometer reads in melting ice above or below 0°. At any time it is the observed reading of the thermometer in melting ice immediately after exposure to the temperature measured. Sometimes it is impossible and it is almost always inconvenient to observe the freezing point of the thermometer immediately after observing a temperature. In such a case the position of the depressed freezing point for that temperature must be computed from the law of the variation of the freezing point. It is always preferable however when the highest accuracy is required to actually observe the freezing point.

[CONCLUDED NEXT MONTH.]

CORRESPONDENCE.

RELATION BETWEEN TORNADOES AND VARIATIONS OF THE COMPASS.

To the Editor:—The following may be of interest as to the possible relation between tornadoes and whatever causes variation of compass. The variation in Missouri was determined by a magnetic survey made by Prof. F. E. Nipher. The number of tornadoes was obtained from Signal Service publications, Missouri Weather Reports, newspapers and individuals. None but genuine twisters were listed. The greatest variation is in the extreme N. W. part of the state, the least in S. W.

On the line of

11°	variation	3	counties	had	7	tornadoes.
10°	"	5	"	"	15	"
9°	"	20	"	"	22	"
8.30°	"	18	"	"	13	"
8°	"	14	"	"	7	"
7.30°	"	23	"	"	8	"
7°	"	11	"	"	5	"
6.30°	"	8	"	"	4	"
6°	"	4	"	"	1	"

J. F. LLEWELLYN.

MEXICO, MO., April 3, 1887.

LETTERS FROM SONORA.

[The following extracts are from letters written by Mr. J. H. Miller.]

* * * We left Deming after the 3d of May, the day of the earthquake. The shock there was quite severe, but nothing serious occurred. On our way down we heard rumors of disaster. At La Asuncion the people were very anxious; at Janos buildings were much damaged, but none destroyed. At Bavispe, on the western slope of the Sierra Madres, the destruction was absolute, not even an adobe was left standing. Forty people were killed outright, or have since died from the effects of their injuries, and 25 more seriously wounded. Bavispe was a town of 1,000 inhabitants. Nearly all the buildings were adobe and one story. So far as I could determine the walls invariably fell outward, as though some internal pressure had been applied. The heavy rafters and mud roofs fell in, crushing those who happened to be within. Bavispe and its vicinity seems to have been the center of the convulsions, although the effects were felt over a wide extent of country. The earth for miles around is scarred with seams and cracks from a few inches to a foot or more in width.

Bavispe is right in the mountains. The main range of the Sierra Madres lies to the east, while off to the west stretches range after range. Those who witnessed the convulsion say that the ranges appeared like waves on the sea, rising and falling, and some toppling over. Fire and smoke and hot water issued from the cracks. The water in the river became scalding hot. The mountains nearest Bavispe have been raised up, and a range beyond has sunk lower. Crevices are discernable in all directions. There is much more water than before. The whole convulsion lasted two minutes. Such a scene of desolation as Bavispe now presents can hardly be imagined. The inhabitants are living in rudely constructed huts of brush, not daring to attempt to rebuild while the *tremblores* continue. I have met here Prof. Clark, of Honolulu, Sandwich Islands, and Dr. Goodfellow, from Arizona, who are studying the effects of the earthquake.

Bacerac is 10 miles above Bavispe, and Guchinera is 10 miles above Bacerac. The buildings in both towns were more or less damaged, but no one was injured. Beyond Guchinera is nothing but unknown country. We intend to cross to Casas Grande. We are told that in that direction (to the S. W. of Casas Grande) there is an active volcano. I doubt this, as I have seen no sign of one. The earth cracked and fire came from these fissures. The mountains are on fire to the south and east, so that any attempts in that direction must be abandoned.

Later.—Sometimes at night the convulsions are so severe that it makes me sea-sick. The earth in the vicinity of Bavispe is full of fissures, some of them wide enough to drive in with horses and wagons, others narrower, but extending for miles on the east side of the mountains.

In Bavispe and Guchinera the people keep up their processions and prayers to their patron saints. Many reports come in of volcanoes, but we cannot find them, and I feel confident that there are none.

The fissures run nearly north and south, following, apparently the mineral belt, showing to my mind that the weakest places are where the mineral veins lie.

Mexicans from Bavispe report that, 15 miles north of there, is a chasm, made by the earthquake, which is 15 miles long and in places 300 feet wide, containing water.

GUCHINERA, SONORA, MEXICO, May 21, 1887.

BRIEF WEATHER REVIEW.

STATION TWENTY MILES S. S. E. OF SAN ANTONIO, TEXAS.

To the Editor.—My review of the weather at this place, published for August, 1885, closed with the month of May of that year.

I resume brief notes of the weather observed here from that time to present date. As useful for reference in connection with the notes that follow, I will first give, in tabular form, the total precipitation for each month as measured here.

TOTAL RAINFALL FOR

	1885.	1886.	1887.
January		0.65	in app.
February		2.08	0.15
March		2.42	0.15
April	series	1.80	0.27
May	begins	0.35	4 25
June	0.25	3.25	5.37
July	6.35	0.30	
August	1.10	4.30	
September	0.25	6.75	
October	0.15	3.50	
November	0.40	0.40	
December	0.97	0.10	

June, 1885, opened with clearing weather, which, with light N. W. winds and gradually rising temperature, prevailed till past the middle of the month. The characteristic upper cloud system that accompanied the storms of the preceding month was wholly absent, and the cirri, when they appeared, seemed of a lower formation, were more diffused and moved *slowly* from north-westerly points, as late as the 22d, from due north. During the last ten days of the month the usual local showers appeared, moving with the wind from S. S. E.

July.—During the last day of the preceding month the barometer rapidly sank two-tenths, and at the same time a heavy bank of cirrus approached from S. W. Increased cloudiness, with light rain, was noted on the 1st, and this was followed on the 2d by a succession of heavy thunder showers that prevailed almost continuously for three days and nights. These storms continued with more or less violence until the 8th, when the sky cleared.

All the rain set opposite the month fell during the first seven days. Throughout these storms the lightning was unusually frequent and severe, with loud and violent explosions of thunder, many bolts passing to the earth.

The storm was most violent in this vicinity during the night of the 2d and 3d.

On a timbered prairie, about six miles south-west of my residence, I noted more than a dozen trees that had received lightning strokes during these storms, all within a mile of each other. This frequent marking of timber I noticed for several miles.

It was at a point where the movement of the storm cloud (which came from S. S. W. nearly) seemed to have been checked, and the clouds spent their force mostly in that region. A low range of hills lies immediately north of the place referred to.

As may be seen from the preceding table, the rainfall was very light during the remainder of the year. The electrical display was less marked than usual, and no feature of special note occurred until December.

December.—A strong norther suddenly began on the night of the 4th, and the weather was variable for some time, the lowest barometer of the month occurring on the 8th, with a heavy rain storm on the 11th.

It seems to me quite probable that there might have been a direct connection between the atmospheric movements observed here at this time and the unusual storms reported about the Isthmus of Panama.

A strong norther, with low temperature, that occurred here about the middle of November, 1879, also appeared simultaneous with violent storms and inundations on the Isthmus.

December, 1885, closed with mild temperature, and the barometer gradually sank after the 25th, while cloudiness among upper strata moving from W. S. W. increased.

January, 1886.—The low barometer of the 1st was accompanied by the peculiar masking of the various cloud strata which seems to result from contact of the latter with reactionary currents, giving the clouds a *blurred* or *trailing* appearance about their inferior edges, so that a broken system of cirro-stratus, cirro-cumulus, or cumulus, even, is made to appear of the texture of stratus or nimbus.

The strong norther of the 2d, 3d and 4th ended with high pressure on the 5th, but on the morning of the 7th the barometer was again low. The weather was calm at sunrise, with a pleasant looking sky. Suddenly a thick fog appeared, lasting an hour, and a little later a strong norther came on, with rapidly falling temperature. The out-door thermometer showed 10° on the morning of the 8th and 14° on the 9th, and during

six days (8th to 13th inclusive) the temperature was barely above 32° at any time. During the night of the 11–12th snow fell to the depth of one inch—the first snow-fall I have known in southern Texas during some fifteen years' observation.

February.—The heavy rain storms of the 21st and 24th ended a period of drouth that began at the close of the thunder storms of the preceding July. For all this time—over seven months—the total precipitation amounted to only 2.87 inches.

March.—Seasonable showers and a moderate temperature characterized this month. Local showers on the 26th formed in a rather smoky-looking sky, the upper strata moving from about due west. Some hail, the size of hens' eggs, and over one inch of water fell, about noon, in the space of ten minutes. There was at the time light wind and light rolling thunder. A light frost followed the norther of the 29th and 30th.

April.—Most of the rain of this month fell during a heavy thunder storm on the 27th. This storm came from the west and was immediately preceded by fresh south-easterly winds and low barometer.

May.—The weather of this month contrasts strongly with that of May, 1885. But a few light showers passed over this place. After the 15th, northerly winds were more constant than usual, and the cirrus cloud was seldom seen.

June.—A heavy thunder storm on the 2d was accompanied by a wind of almost hurricane force from the west. Another storm of much the same character passed over from the north late on the evening of the 27th. The temperature on the 15th reached 101°, and the air was unusually sultry and oppressive. The wind, as is often the case in extremes of heat at this season, was light and northerly.

July.—During the first half of the month, south-easterly winds prevailed, and almost daily heavy masses of cumulo-stratus approached from the south with considerable thunder. There was little rain, however, no cloud reaching the zenith. After the 15th this cloud formation lessened and retired and the higher strata at the close of the month moved from northerly points. The days noted of maximum temperature were the

16th, 17th and 18th—100°, 101°, 105° respectively. During the last sixteen days the mid-day maximum was below 95° but once.

August.—The unusually high temperature of July continued with little abatement until past the middle of this month.

The sandy soil about my residence showed a temperature of 135° at the surface at mid-day; and in many places not a trace of moisture could be found to the depth of four feet. The nights were generally dewless, grass was literally scorched, and the forest trees in many instances withered.

The barometer fell very gradually after the 9th, with light easterly winds. As is usual at this season, the cirri moved from the north very slowly. There were light thunder showers on the 11th, the cumuli from south-east, the upper strata from north.

On the 18th cumulo-stratus with thunder was noted south-eastward. Early on the 19th the wind freshened from east; at the same time a bank of cirrus appeared above the eastern horizon, while cumuli were seen to form and move more rapidly than usual. Some of the cumuli were "capped;" the cirrus bank had spread to the zenith at mid-day. A few hours later a heavy cumulo-stratus arose from N. E., bringing a sharp thunder shower, 5–6 P. M.—the sun still shining. At sunset it was noted the cirri and cirrus strata had greatly increased and thickened at all points. Moreover the cumuli tended to pass into cumulo-stratus and lightning appeared from all directions.

20th. At 5 A. M. the sky was found wholly overcast by a thick lead-colored upper stratum, darkest eastward. Next below there was drifting a rapidly increasing mass of cirrus stratus from N. E. The lowest stratus came with the wind from about N. N. E. The barometer had fallen about one-tenth during the night and was about two-tenths below its mean. A light but continually increasing storm of wind and rain began at 6 A. M. The wind blew for a long time from about due N., then from N. to N. W. shifting to west, when the storm reached its greatest fury, about 12:30 P. M.

During the storm the barometer fell nine-tenths of an inch in about five hours, reaching a point on the scale six-tenths below any previous reading of the instrument for the past four

years. At 9 A. M. the force of the wind was that of a strong gale. There was a steady increase in both the force of the wind and the rainfall during the next three hours.

At 10–11 A. M. the violence of the wind became alarming. At San Antonio its force was estimated at about 80 miles per hour, and houses not well built were destroyed. Here the stoutest timber, even the live oak, was broken down or uprooted on all sides. I think most of the forest trees here would have been uprooted if the ground had not been hardened by the long previous drouth. No such wholesale destruction of timber by wind was ever before known in this region.

The wind came in gusts of greater force at intervals of ten to fifteen minutes, and just after a sudden fall of the mercury in the barometer, which, at such times, sank one-tenth or more, so rapidly the eye could follow its movement.

I much regret that, owing to my imperfect shelter, which wholly prevented the use of writing materials, I was unable to register the movement of the barometer at short intervals during this extraordinary storm.

No lightning or thunder was observed during this storm, but light thunder showers passed over from south the night following. The rainfall of this storm was 4.15.

Local thunder storms of small extent, moving from about due north, formed on the 24th. One of these at San Antonio and another about six miles south-west of my residence exhibited a destructive wind, which, in the latter instance, was accompanied by a heavy fall of hail about one inch in diameter. These storms showed characteristics of incipient tornadoes.

September.—Rain fell copiously at short intervals throughout the month. The lightning and thunder were unusually severe on the 12th and 14th.

The showers on the evening of the 14th moved from the west, and distinct from the incessant roll of thunder a singular roaring, like the sound of distant wind or water in rapid motion, was heard in the cloud for several hours.

On the 20th, and for three days following, there was fresh wind from E. N. E. During this time cirri attended by cirrus

strata and cumulus strata of great density approached from the south-east horizon. This appeared as the edge of a great storm lying some distance south-eastward.

The first norther began on the morning of the 28th and was attended by heavy showers as the upper cloud from the south was driven back.

October.—A heavy thunder storm on the evening of the 24th appeared to close a period of unusually heavy rainfall, 14.55 inches having fallen since August 20, inclusive.

November.—A clearing norther began on the 23d, followed by the first frost of the season.

December.—The lowest temperature of the month (17°) was observed at sunrise of the 5th and 6th. The weather of this month was pleasant and mild until the 31st, when there occurred a strong norther.

1887.—Almost continuous northerly winds, often accompanied by falling barometer, prevailed during the first half of the month.

The average morning temperature of the first five days was 24.2°. Until about May 1 the rainfall was insignificant in this region, strong, dry northers appearing every few days.

A decided fall in the barometer and rise in temperature was noted during the last three days of April, and on May 1 the pressure was three-tenths below the mean, and the maximum temperature reached 100°.

Small patches of upper clouds appeared N. W. and W., with lightning, about sunset, and on the 2d a connected system of upper clouds, including cumulo-stratus, was passing from south to north all day. Heavy thunder storms appeared in sight south-eastward.

Here the long drouth was first broken by a heavy thunder storm from the west on the 9th.

Since this to the present date rain has fallen in frequent and copious showers, and currents from the Gulf seem to control the weather to an unusual extent. Apart from the unusually prolonged drouth, accompanied by exceptionally persistent

northers, there have been noted some peculiar features in the weather of the present year since a rainy period began.

There has been an entire absence of a class of storms that might be termed reactionary—when south-east winds are accompanied by more or less fall of the barometer, which fall becoming more rapid, ends with the passage of heavy thunder storms from westerly points (usually occurring at night) and followed by clearing weather. Instead of such movements there has thus far been noted a decided increase of pressure with the advent and continuance of south-easterly winds, and the storm-iest days have been immediately preceded by a rise in the barometer of one or two-tenths (often above the mean).

I may also remark that so far all this year the barometer has oftener than usual tended downward during northerly winds. For the past two months the *filling* after low barometer seems almost invariably from tropical regions, *i. e.*, from south-easterly winds.

I recall a parallel of this rather anomalous movement of the barometer from my observations at Ann Arbor during the remarkably wet summer of 1855. A series of copious and almost incessant rains began about July 10, continuing about 30 days, and, as many may still remember, doing great damage to the wheat crop of that year over a large area. At the commencement of these storms the barometer had risen several tenths above its mean, and was still rising, with light southerly winds. Before the approach of the reactionary storms that closed the series, however, there was a decided fall of the barometer.

The warmest day of the year, so far, was June 2, when the mercury reached 102°. Except in periods of confirmed drouth a few days of exceptionally high temperature are usually soon followed here by more or less rain. Light thunder showers form here now almost daily, with prevailing south-easterly winds. Upper strata have little motion, generally tending from north-east. LUM WOODRUFF.

BEXAR CO., TEXAS, July 4, 1887.

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